Vol. XLIV NOVEMBER, 1960 No. 6

THE PHILIPPINE AGRICULTURIST

JOURNAL OF THE COLLEGE OF AGRICULTURE
AND CENTRAL EXPERIMENT STATION
University of the Philippines

CONTENTS

Irrigation and Drainage in Lowland Rice Production ..... *A. P. Aglibut, F. L. Valbuena, and A. A. Caoili* 271

A Preliminary Study on the Cancellation of Dormancy Period of Rice Seed ..... *D. L. Umali, M. B. Parker, and R. C. Dumlao* 279

A Cytogenetic Study of Bush Sitao and Its Parental Types ..... *E. T. Floresca, J. M. Capinpin, and J. V. Pancho* 290

Mutants Isolated from X_1 and X_2 Generation of Rice (O. Sativa) ... *Filomena F. Campos and Lucila G. Espiritu* 299

The Spectrographic Analysis of Trace Elements in Some Philippine Soils ... *S. A. Cuyson, A. T. Violanda-Calo, and R. R. Covar* 308

NOTE:

Attempts at Applying Nutrients Through Rice Leaves ..... *F. C. Manuel and R. S. de la Peña* 323

UNIVERSITY OF THE PHILIPPINES PUBLICATIONS SERIES A
Published at College, Laguna

COMMONWEALTH OF AUSTRALIA
14 APR 1961

The Philippine Agriculturist

Journal of the College of Agriculture and Central Experiment Station
University of the Philippines

EDITORIAL STAFF

FAUSTINO T. ORILLO, Editor
ROGELIO D. FELICIANO, Acting Associate Editor
THOMAS G. FLORES, Business Manager
SILVERIO M. CENDAÑA, Animal Sciences
NICOLAS L. GALVEZ, Physical Sciences
PEDRO B. ESCURO, Plant Sciences
GIL F. SAGUIGUIT, Social Sciences
SANTIAGO M. ALVIAR, Statistics

ADMINISTRATIVE STAFF

DIOSCORO L. UMALI ..... Dean
ANDRES P. AGLIBUT ..... Director of Business Affairs
GIL F. SAGUIGUIT ..... Director of Instruction
FAUSTINO T. ORILLO ..... Director of Research
JOSE M. CAPINPIN ..... Head, Department of Agricultural Botany
LEOPOLDO J. VILLANUEVA ..... Acting Head, Department of Agricultural Chemistry
EMILIO U. QUINTANA ..... Head, Department of Agricultural Economics
MARTIN V. JARMIN ..... Head, Department of Agricultural Education
DANTE B. DE PADUA ..... In Charge, Department of Agricultural Engineering
VALERIANO C. CALMA ..... Head, Department of Agronomy
GONZALO V. GARCIA ..... Assistant Head, Department of Animal Husbandry
CLEMENCIO O. PEÑA ..... In Charge, Department of Entomology
AMPARO G. RIGOR ..... In Charge, Department of Home Technology
EDELWINA C. LEGASPI ..... Head, Department of Languages
VICTORIA M. ELA ..... Acting Head, Department of Plant Pathology
JORGE G. DAVIDE ..... In Charge, Department of Soils

THE PHILIPPINE AGRICULTURIST is published monthly except in April and May by the College of Agriculture and Central Experiment Station, University of the Philippines, College, Laguna. The subscription price is ₱6.00 a year in the Philippines and $4.00 (U.S. currency) elsewhere; the price of single copies, ₱0.75 in the Philippines and $0.50 elsewhere.

Authors of articles appearing in THE PHILIPPINE AGRICULTURIST are severally responsible for the opinions expressed therein.

Publications sent in exchange for THE PHILIPPINE AGRICULTURIST should be addressed to the Library of the College of Agriculture and Central Experiment Station, University of the Philippines.

Entered at the Post Office at College, Laguna, Philippines, as second-class mail matter.

IRRIGATION AND DRAINAGE IN LOWLAND RICE PRODUCTION [1]

A. P. Aglibut, F. L. Valbuena, and A. A. Caoili

In the Philippines, rice is grown under dryland or upland and wetland or lowland conditions. Rice grown in either case is commonly dependent upon rainfall so that generally, raising rice crop is only possible during the rainy season. However, with adequate irrigation facilities, the rain-fed areas can also be cropped during the dry season.

The importance of controlled irrigation in lowland rice production cannot be overemphasized. With adequate irrigation, there is less dependence upon rainfall and better assurance of good crop because of : (1) timely and thorough preparation of the seedbed and the field, (2) timely application and thus more effective use of fertilizer, and (3) better control of weeds due to an adequate supply of water and timely submergence. These, together with good control of pests and diseases and favorable weather would insure good yield and better income for the farmers.

Realizing that irrigation is a major factor in enhancing the production of agricultural crops, the government has invested millions of pesos for the improvement and extension of irrigation facilities throughout the Islands. If these systems could provide adequate water, and if this water is properly utilized in lowland rice production, the country would become self-sufficient in rice and may even have some for export in the future.

WHEN IRRIGATION IS NEEDED

There are two main periods in the production of lowland rice when water is indispensable: (1) during the preparation of the seedbed and the paddy field, and (2) during the growth of the seedlings in the seedbeds and the development of the crop in the paddy.

Preparing the seedbed and paddy field. If both the seedbed and paddy field are prepared by the wet method, it is necessary that the soil be submerged in water and softened from three to five

[1] General Contribution No. 911.

days before plowing. During plowing, the water depth is reduced to a thin sheet above the soil surface. Soon after plowing, the depth is increased to a level just enough to cover all clods and weeds for seven to ten days. This will help kill the weeds and prevent the clods from getting hard.

Harrowing, aimed at breaking the clods and piercing the decaying weeds, follows plowing. During this operation, the water is again reduced to a thin sheet. A second harrowing follows, during which all remaining clods and weeds are resubmerged in water for five to seven days. The third and final harrowing is done five days after the second with the soil surface barely covered with water. The field is then leveled, drained of excess water, and the seedbed is ready for seeding. In preparing the paddy field, the steps in preparing the seedbed may be followed.

Irrigating the seedlings. The seedbed is first irrigated by admitting a slow flowing shallow sheet of water over the field four days after seeding. Flushing with water is made once every two to four days until the seedlings are tall enough to stand a shallow submergence of the ground surface. The flowing or stagnant water is then gradually increased in depth to prevent the germination of weed seeds. Flooding irrigation, lasting three to five days, is alternated with drainage of three days duration until the seedlings are ready for transplanting. The final flooding, which makes for easier pulling of the seedlings and faster and better washing of the roots, lasts until all the seedlings have been removed from the seedbed.

Effects of water in the paddy during transplanting. Although some farmers transplant the seedlings in paddy submerged in water three to 15 centimeters deep, many prefer to transplant them in drained paddy, leaving just enough water with which the planters can wash their hands and the seedlings. Transplanting with water in the paddy was observed to be more beneficial to the recovery and growth of seedlings. However, if proper planting is not done, i. e., the holes formed by the fingers in inserting the seedlings are not filled or plugged with mud, some of the transplants float. Consequently, transplanting with the soil submerged slows down, and more hills are liable to be replanted later.

When to start irrigation. The time of starting to irrigate a newly transplanted paddy is very important. Early irrigation is

advisable. Delayed irrigation, especially if the field had been drained at transplanting, retards the recovery of the young transplants and causes more drying. It also enables the weed seeds to germinate and grow. However, if delayed irrigation is inevitable, transplanted paddies should be flushed with a shallow sheet of water within three to five days after transplanting.

METHODS OF IRRIGATION

Continuous irrigation. This method is commonly called *continuous flooding* or *continuous submergence.* The field is continuously submerged in the desired depth of water from the start of irrigation until the crop matures and is about ready for harvest.

The depth of the water in the field may be maintained in two ways: (1) by keeping a slow but continuous inflow of the water on one side of the field, and a continuous exit on the other. (This is preferred when there is enough water to meet the demand and when provisions for proper drainage are made possible because the plants have free access to fresh water supply), (2) if the water supply is limited, by a periodic addition of water in the paddy field.

Some farmers use continuous flooding because it provides for a better control of weeds and an easier management of the irrigation water. Others adopt it because of the poor or lack of drainage facilities of their fields. Rice fields with poor drainage systems are usually located in low places where excess rain water in the form of run-off or drainage water from higher paddies accumulate.

Intermittent irrigation and drainage. The paddies are repeatedly irrigated and drained, with or without a definite duration between the processes, until a few days before the booting stage. This method of irrigation is applicable in rice fields where water is adequate and can be regulated properly.

Intermittent irrigation and drainage is divided into two categories. The first is called *cyclic intermittent irrigation and drainage* because a continuous cycle of submergence and drainage is followed. From the first irrigation, the paddies are submerged for any of the following periods: 5, 10, 15, or 20 days. After this period, drainage lasting for 5, 7, or 10 days follows. A combination of an irrigation and a drainage period may be selected. The cycle is continued from the first irrigation until the last drainage which should end a few days before the boot stage. In general, a 10-day irriga-

tion and 5-day drainage cycle from the start of irrigation until the plants begin to boot is recommended for common types of paddy soil. During the boot, head and dough stages, the paddy should be submerged in water to keep pace with the increased rate of water use. Common experience shows that drying the soil at these stages will likely impair the development of the grains.

The second category is called *ordinary intermittent irrigation and drainage*. The paddy field is drained as many as four times starting from the first irrigation until a few days before the boot stage of the crop. There are no definite durations of irrigation and drainage. Many farmers use this method, with two or three drainage periods having about the same duration.

Results of several studies on the effect of time, duration, and frequency of drainage conducted in the Central Experiment Station showed that the number of drainage may be increased to four, and their duration can be varied depending upon the stage of growth of the plants. The following is a recommended *intermittent irrigation and drainage* process for medium maturing varieties of rice.

The first irrigation begins from one to three days after the seedlings are transplanted and lasts for 10 days. The depth of the water in the paddy varies from 5 to 10 centimeters. The first drainage, having a duration of five days, follows.

If the rice in the paddy is given a single application of fertilizer, it may be broadcast immediately after transplanting or before the first irrigation is applied. However, if split application is followed, a part may be applied one or two weeks or immediately after transplanting and the rest, before the boot stage of the plants. For additional information on proper fertilization, the advice of the local extension agriculturist should be sought.

After the first drainage, the paddy is resubmerged in the same depth for 10 days. As much as possible, the water should be kept stagnant during the first two days in order to retain the fertilizer in the paddy. The second five-day drainage then follows the second irrigation. This is about 30 days after transplanting. Cultivation and weeding may be performed during this period.

The third irrigation which follows the second drainage is 5 to 10 centimeters deep and lasts for 10 to 15 days. It is followed by the third drainage which lasts for 10 days. The duration is prolonged

because by this time, the plants have sufficiently tillered and grown to cover the ground space between the hills and depress weed growth. However, all remaining weeds should be removed and the paddy cultivated for the second time.

The fourth irrigation may have a duration of 10 to 15 days. The fourth drainage, now about the boot stage, may last for 10 to 15 days, long enough to permit good soil aeration and to inhibit the growth of new tillers. The second or last dressing of fertilizer may be done at the end of this long drainage. The last irrigation is then maintained until the late dough stage. This will provide the plants with an adequate supply of water which they greatly need at this stage. After this period, the water may be removed in preparation for harvesting the crop.

If late maturing varieties are grown, this recommended intermittent irrigation and drainage process may be followed, except for some variations. The frequency of irrigation and drainage should be increased, at the same time keeping their duration the same or, the period of irrigation should be increased, but keeping their frequency the same. In either way, it is a good practice to have the last pre-booting drainage long enough to provide a thorough aeration of the soil.

TERMINAL OR FINAL DRAINAGE OF THE RICE PADDIES

The time to start terminal drainage is just as important as the time to start submerging the paddies. If the terminal drainage is begun too early, the yield may decrease because some grains would not fully develop. Milling recovery and quality would also be reduced because the immature grains would be chalky and pulverized during milling. On the other hand, if the last drainage is started late, more grains become over-ripe, causing a greater reduction in yield during harvest due to shattering, and checking of the grain reduces the milling yield and quality.

Proper timing of terminal drainage without severe effect on the development of the grains may depend on two factors: (1) season of planting; and (2) moisture-holding capacity of the soil. Terminal drainage can be started earlier when the plants are grown during the wet season than when they are grown during the dry season. Rainfall will add moisture to the soil. It can also be started earlier for soils having good moisture-holding capacity.

Studies undertaken in the Central Experiment Station to determine the effects of early post-heading drainage showed no significant differences in the maturity, grain yield, milling yield, and quality of Milfor 6(2) and Peta, when terminal drainage took place at heading time, 5, 10, and 15 days later. Except for slight interference of rain in some plantings done during the rainy seasons, the soil could have stored enough moisture to last during the period between the early drainage and harvest to produce normal crops. Possibly, different results could have been obtained in soil having low moisture-holding capacity and good internal seepage.

These studies show evidence of saving irrigation water by starting the terminal drainage of average paddy soil earlier than the usual practice of doing it, that is, 10 to 15 days before harvesting.

For soils with low moisture-holding capacity, it would be safe to stop flooding and gradually drain the paddies as soon as the panicles are well bent. At this stage, the grains at the upper half of the panicles are just turning yellow and those at the base are at a soft-dough stage. Harvesting may take place 10 to 15 days later. The ground would then be dry enough to allow even the use of mechanical harvesting equipment.

DEPTH OF THE WATER IN THE PADDIES

The effects of depth of the water used in irrigating lowland rice, either continuously or intermittently, have been thoroughly investigated in the Central Experiment Station and in some experiment stations of the Bureau of Plant Industry. Practically in all cases wherein 5, 10, 15, or 20 centimeters deep of irrigation were used in both methods, no significant differences in grain yield, tillering and growth were observed. Thus, deeper irrigation may be used when the water supply is plentiful and cheap. However, when irrigation water is limited and expensive, as in pump irrigation, it is best to have a depth of only 5 to 10 centimeters. Shallow irrigation will not only conserve water but will also increase the area that could be irrigated effectively.

Since one of the main uses of water in rice production is to help depress, if not entirely control, the growth of weeds particularly grass weeds, deeper irrigation is recommended. It has been observed that during the early stage of plant growth, when the weeds also grow fast, the paddies submerged 15 to 20 centimeters were less weedy than those submerged 5 to 10 centimeters.

CONTINUOUS AND INTERMITTENT FLOW OF WATER IN RICE PADDIES

Where water is abundant, the usual practice among rice farmers is to irrigate their fields with the water continuously flowing from the higher through the lower paddies. While some farmers obtain better grain yield from this practice, others do not get a yield greater than those making use of the occasional addition of water to maintain the desired depth in the paddies. In conserving water and consequently increasing the area that an irrigation system can irrigate, many farmers practice intermittent flow by periodic addition of water into the paddies. In most of the rain-fed paddies, the water is not always in continuous flow, but it is impounded in the paddies by the dikes between rains. With this practice, some copiously rain-fed paddies produce as well as those paddies irrigated with the water continuously flowing.

CONTINUOUS IRRIGATION VERSUS INTERMITTENT IRRIGATION AND DRAINAGE

Studies which primarily dealt with the irrigation of lowland rice had frequently shown variable results. Some showed that intermittent irrigation and drainage gave better grain yield than continuous irrigation; others showed that the latter gave higher yield than the former; and still, others indicated that one method is just as good as the other. At the Central Experiment Station, Tjeremas, Peta and Milfor 6(2) were found to produce as many tillers and as much grain yield when irrigated continuously as when irrigated and drained intermittently. In one study however, Tjeremas gave higher yield in intermittent than in continuous irrigation, when the duration of drainage was prolonged to 10 and 15 days. These contrasting results no doubt show that the influence of drainage on rice is dependent upon the kind of soil, and the changes it brings about on the supply of nutrients from the soil.

Nevertheless, intermittent irrigation and drainage has the following advantages over continuous irrigation: (1) it makes farmers follow improved water management; the farms in an irrigation system could be grouped into sections, each to be provided with a definite irrigation schedule, (2) a larger area can be irrigated effectively because of more equitable distribution and economical use of water, and (3) better grain yield could be obtained under certain soil conditions.

IRRIGATION AS RELATED TO THE LODGING OF RICE

Lodging is mainly a varietal characteristic of the rice plant, hence it is not necessarily influenced by water management. However, if the nature of lodging shows association with prolonged submergence, the management of water should be modified. More frequent drainage with shorter duration or less drainage with longer periods have been observed to be quite effective in reducing the number of plants that lodge. When lodging is caused by natural factors such as rain and strong winds, the paddy should be drained. Periodic flushing of the paddy should be preferred over prolonged flooding.

BIBLIOGRAPHY

AGLIBUT, A. P. 1955. Regulate water use for higher duty, yield. U.P. College of Agriculture Monthly Bulletin **20** (5): 2.

————. 1957. Use and management of irrigation water for rice production in foreign countries. Philippine Agriculturist **41** (1-2): 1-7.

————. 1958. Progress report on irrigation practices of Philippine rice farmers. U.P. College of Agriculture Monthly Bulletin **23** (6): 6.

————. 1958. Some problems of irrigation in rice culture. Jour. Soil Sci. Soc. Phil. **10** (2-3): 52-60.

————, A. B. CATAMBAY, H. E. GRAY, and P. R. HOFF. 1957. Measurement of consumptive use of water by lowland rice. Philippine Agriculturist **41** (7): 412-421.

———— and P. R. HOFF. 1956. Effects of continuous and discontinuous submergence on rice lodging and yield. Philippine Agriculturist **33** (8): 453-464.

CAOILI, ABRAHAM A. 1958. Effects of continuous submergence and late preheading drainage on growth, tillering, and yield of Milfor 6(2). Undergraduate Thesis. Unpublished.

CATAMBAY, A. B., H. E. GRAY, A. P. AGLIBUT, and J. L. ORDOVESA. 1959. Effect of continuous submergence of various depths of irrigation water on the growth and yield of lowland rice. Philippine Agriculturist **42** (8-9): 358-363.

GREGORIO, REGALINO P. 1958. The effects of time of starting continuous submergence upon the prevalence of weeds and growth, tillering and yield of Milfor 6(2). Undergraduate Thesis. Unpublished.

MATSUO, T. 1955. Rice culture in Japan. Tokyo: Yokendo, Ltd.

POUNAMPERUMA, F. N. 1955. Chemistry of submerged soil in relation to the growth and yield of rice. Graduate Thesis, Cornell University. Unpublished.

VALBUENA, F. L. 1958. Studies on the germination and emergence of four commercial lowland rice varieties from different water depths on unpuddled and puddled soils. Undergraduate Thesis. Unpublished.

VILLAROYA, R. G. 1959. Effects of frequency and depth of submergence upon the growth, tillering and yield of Peta, and upon weed vegetation in paddies. Undergraduate Thesis. Unpublished.

A PRELIMINARY STUDY ON THE CANCELLATION OF DORMANCY PERIOD OF RICE SEED [1]

D. L. Umali, M. B. Parker, and R. C. Dumlao [2]

Smoking dormant seeds for at least 84 hours totally broke the rest period of Peta, a recommended variety of lowland rice. Another promising method of breaking dormancy which needs further investigation is exposing dormant seeds to a mixture of calcium carbide and formalin for 12 hours or less.

Experiments on sulfuric acid scarification, dehulling, and soaking in hot water suggest presence of germination inhibitors in the seeds, most probably in the seed coat.

The prolonged dormancy period of certain rice varieties is a most irksome problem in seed production and certification. Freshly harvested rice will be certified only if it has a minimum germination of 80 per cent. But because of the dormancy period of seeds, it takes at least two months before the laboratory analysis of seed samples can be released.

Farmers who use newly harvested seeds for planting sometimes obtain very low or no germination. Seeding operation has to be repeated, resulting in delay in schedule and additional expenses. The delay in turn causes the planting to be attacked by pests and diseases which are then more prevalent. A rice breeder who wishes to hasten his breeding program by immediately planting seeds from recent harvest also suffers from this problem. If the seeds he uses are still dormant, his breeding materials may be lost.

Schwendiman and Shands (1943) reported that the use of a 0.2 per cent solution of potassium nitrate for moistening the germination blotter was as effective as prechilling in overcoming delayed germination of oats. Likewise, Johnson (1935) noted that potassium nitrate, increased oxygen pressures, and lowered germinating temperatures increased the germination of *Avena fatua*. He

---

[1] Central Experiment Station Contribution No. 2056. Part of Project No. 3 of the Rice and Corn Program.

[2] The writers are grateful to the staff of the Department of Animal Husbandry for making their smoke chamber available, and to Dr. P. B. Escuro, Messrs. I. S. Santos, F. A. Bernardo, O. Q. Ballesteros, and Miss D. A. Ramirez for their suggestions in the preparation of the manuscript.

suggested that the stimulation by potassium nitrate might result from (1) a direct germinative stimulation by absorbed anion, (2) indirect effects of the absorbed anion such as increased utilization of stored carbohydrates, or (3) chemical effects upon the seed coat which produce increased permeability to oxygen. Nitrate and other nitrogen compounds hastened seed germination, especially in many seeds which needed light for germination but which were probably buried too deep to receive it (Crocker, 1936). Burk (1957) noted that a two per cent sodium hypochlorite (NaOCl) used for soaking dormant seeds for 15 to 30 minutes was effective in increasing germination in a number of *Nicotiana* species. Emparan and Tysdal (1957) found that exposure of guayule seeds to light for three to four days during germination plus oxidation through the use of three-fourth per cent sodium hypochlorite completely broke dormancy.

Harrington (1923) increased germination of wheat, oats, and barley by artificial drying, opening the coat structure over the embryo with incidental wounding of the scutellum, cutting off the distal end of the caryopsis, removing the lemma and palea, weakening the coat structure over the embryo with the use of sulfuric acid, increasing the oxygen pressure in the atmosphere, and germinating the seed at 12° to 16°C.

Goodsell (1957) obtained normal germination in sorghum by breaking the seed coat or by mechanical scarification, and by a hot water treatment of short duration (70°C for 4 minutes). Williams (1958) also found that scarification with sulfuric acid increased germination of Bahiagrass. Walhood (1956) noted that a water-soluble or heat-unstable inhibitory substance in dormant cotton seeds could be removed by hot water treatment.

Ramiah and Rao (1953) reported that cool smoke emitted by burning coconut coir for a couple of hours a day for three days improved germination (up to 80 per cent) of rice seeds harvested 20 days before.

Many published experiments about overcoming delayed germination were on a number of seed crops other than rice. Therefore, this study aims to explore certain means by which dormancy in rice can be overcome and to find out if the methods reviewed above have the same effect on the dormant rice seed.

The study was conducted from November, 1958 to November, 1959 at the Division of Plant Breeding, Department of Agronomy, U.P. College of Agriculture.

MATERIALS AND METHODS

Chemical Treatments

A two-week old harvest of Peta seeds, a recommended lowland rice variety, was used in this study. This variety has been observed to have an estimated dormancy period of seven weeks. One set of two 100 well-filled grains each was soaked in three different concentrations (0.25%, 0.50%, 1.00%) of $(NH_4)_2SO_4$, KNO_3, and DDT for 10, 20, 30, and 60 minutes.

Another set of seeds was soaked in pure commercial form of chlorox (5.5 per cent sodium hypochlorite) and a third one in a solution diluted to 50 per cent. The seeds used in the last two sets were soaked for 15, 30, 45, and 60 minutes. Two replications were used on each set.

After the desired period of soaking, the seeds were immediately germinated in Petri dishes provided with moist tissue paper.

Physical Treatments

Acid scarification. Two replications of 100 well-filled grains each of the same harvest were soaked in concentrated and diluted (50%) sulfuric acid for 5, 10, 15, and 20 minutes. Seeds were washed thoroughly in running water for 5 to 10 minutes before they were germinated.

Dehulling. Several seeds of the same harvest were dehulled by hand and from these, the following sets were prepared: (a) two 100-seed lots with embryos excised, (b) two 100-seed lots with endosperm reduced to one-half, and (c) whole kernels. These and the unhulled seeds were immediately germinated in Petri dishes with moist tissue paper.

Other Treatments

Hot-water treatment. The same two-week-old harvest was used. Two replications of 100 well-filled grains each were soaked for 10, 20, and 40 minutes in ordinary tap water (34°C), and in water at 40°C, and at 60°C. Seeds were immediately germinated in Petri dishes with moist tissue paper.

Smoking. In December, 1958, a two-week-old harvest of the same variety was exposed to smoke. Seeds were contained in small cheesecloth bags and placed in the smoke chamber of the Department of Animal Husbandry for 3, 6, 9, and 12 hours. The temperature inside the chamber was maintained at a maximum of 120°F (48.9°C). Smoke generated by ordinary acacia wood was continuously directed to the chamber.

Another set composed of freshly harvested seeds of the same variety was subjected to the same treatment but with increased length of exposure to smoking. This set was subdivided into two treatments, each replicated three times. One treatment was first immersed in water for five minutes before being smoked and the other was smoked without any pretreatment. Duration of exposure ranged from 10 to 87 hours. Seeds were germinated immediately after being soaked.

A control lot (control I) was germinated simultaneously with the samples exposed to the shortest duration, and another lot (control II) simultaneously with the samples having the two longest durations.

To further test the effectiveness of smoking in breaking the rest period of rice, another set of freshly harvested Peta seeds was smoked for 24 to 168 hours. Seed lots were placed inside the smoke chamber in a well-planned time interval, that is, in a manner whereby the seeds were taken out of the chamber and germinated all at the same time.

A control lot was also germinated together with the smoked seeds in Petri dishes provided with moist tissue paper.

Subjecting seeds to some chemical components of smoke. To isolate the constituent or constituents of smoke responsible for eliminating the rest period of rice, another set of newly harvested Peta seeds was subjected to other commercial sources of some chemical components (combined or singly) like formaldehyde and acetaldehyde. Pettet and Lane (1940) reported that these two chemicals are among the seven chemical components of ordinary wood smoke, like acacia, which were used in the smoking experiment.

Formalin, a 40 per cent formaldehyde solution in water, was used as a source of formaldehyde, calcium carbide as a source of acetylene which in turn yields acetaldehyde and ketones, and acetylene gas which is used for welding as a source of acetylene alone.

Seeds placed in small cheesecloth bags were exposed for 12 to 48 hours to: (1) a mixture of formalin and calcium carbide (40 ml. formalin to 20 grams calcium carbide), (2) a mixture of calcium carbide and water (40 ml. water to 20 grams calcium carbide), (3) Calcium carbide (20 grams), (4) Formalin (40 ml.), and (5) Acetylene gas.

These different mixtures were contained in one-half gallon ball jars wherein the seeds in cheesecloth bags were hung. Ball jars were kept in a closed room and closed as tight as possible to prevent the escape of any gas or heat.

EXPERIMENTAL RESULTS

Effect of Chemical Treatment

Tables 1a and 1b show the effects of the four chemicals in breaking the dormancy period of rice. None of the three chemicals affected germination (table 1a). The reaction to the increase in concentration of and in length of soaking in the chemicals was inconsistent. Sodium hypochlorite seemed to retard rather than hasten the germination of rice seeds (table 1b).

TABLE 1a.—*Germination percentage of dormant Peta seeds at various lengths of soaking in different concentrations of three chemicals*

CHEMICAL AND CONCENTRATION	LENGTH OF SOAKING (min.)			
	10	20	30	60
$(NH_4)_2SO_4$				
per cent				
1.0	15.5	17.5	17.0	20.0
0.5	18.5	14.5	12.5	21.5
0.25	8.0	13.0	17.5	13.5
0	23.5	20.0	17.0	17.0
KNO_3				
1.0	13.5	15.5	18.0	11.0
0.50	15.5	25.0	16.0	11.0
0.25	17.0	23.5	17.5	14.0
0	23.5	20.0	17.0	17.0
DDT				
1.0	17.0	18.5	11.0	19.0
0.50	16.0	17.5	12.5	16.0
0.25	12.5	13.5	10.5	16.5
0	23.5	20	17.0	17.0

TABLE 1b.—*Germination percentage of dormant Peta seeds at various lengths of soaking in NaOCl*

TREATMENT	LENGTH OF SOAKING (min.) 15	30	45	60
Control	3.0	3.0	3.0	3.0
Diluted to 50%	0.5	1.5	0	1.0
Concentrated	1.0	2.0	1.5	0.5

The results of this study indicate that none of the chemical treatments (chemicals, concentration, and length of soaking) applied induced germination of dormant seeds; instead, all tended to retard it. One possible cause was the toxicity of the chemicals used on the young embryo.

Effect of Physical Treatment

Acid scarification. As the length of soaking seeds in concentrated sulfuric acid was increased to 20 minutes, germination also consistently increased (table 2a). A little more increase in length of soaking might bring the germination percentage to 80, which is the minimum for non-dormant seeds (Buenaventura, 1956). Response to 50 per cent sulfuric acid as length of soaking was increased was erratic.

TABLE 2a.—*Germination percentage of newly harvested Peta seeds scarified with sulfuric acid*

TREATMENT	LENGTH OF SOAKING (min.) 5	10	15	20
	per cent			
Concentrated	23.5	38.5	45	64.0
Diluted to 50%	0	36.5	12	36.0
0	17.0	23.5	20	17.0

Dehulling, reducing endosperm to one-half, and excising embryo. Dehulling and at the same time reducing the endosperm to one-half successfully broke dormancy, the mean germination being above 80 per cent (table 2b). All the treatments increased the percentage of germination of the dormant seeds. It seemed apparent that the rice hull may serve as a barrier to germination or that it may contain inhibitory sustances. It is also possible that a portion of the kernel may play an important role in delaying the germination of

TABLE 2b.—*Germination percentage of newly harvested Peta seeds dehulled by hand, endosperm reduced to one-half and embryo excised*

TREATMENT	REPLICATION		MEAN
	I	II	
Unhulled	20.1	17.0	18.5
Whole kernel	55.5	81.5	68.5
Endosperm reduced to one-half	80.5	88.0	84.2
Excised embryo	49.0	53.5	51.2

rice as shown by the difference in mean germination of the whole kernels and those whose endosperms were reduced to one-half. Values for replications I and II on the unreduced endosperm were so different, however, that reducing the endosperm might have had no effect.

Effect of Hot Water Treatment

Table 3 shows the effect of hot water on the germination of dormant Peta seeds. At a 40-minute soaking, as the temperature of the water was increased from 40°C to 60°C, there was an increase in germination percentage.

TABLE 3.—*Germination percentage of newly harvested Peta seeds treated with hot water*

TREATMENT	LENGTH OF SOAKING (min.)								
	10			20			40		
	I	II	Mean	I	II	Mean	I	II	Mean
Ordinary Tap									
H_2O	23	24	23.5	19	21	20.0	17	23	20.0
40°C	17	28	22.5	15	27	21.0	27	24	25.5
60°C	11	30	20.5	18	29	23.5	31	40	35.5

Effect of Smoking

In general, higher germination percentages were obtained as duration of exposure to smoke was increased (tables 4a, 4b, and 4c).

The dormancy period of Peta was broken when the seeds were exposed to smoke for 87 hours (tables 4b and 4c). Ashbrook (1954) observed, as one of the effects of smoke on meat, a diminution or reduction of chemicals, particularly nitrate, brought about by the aliphatic diazo reaction with protein at higher temperature. If in-

TABLE 4a.—*Germination percentage of smoked dormant Peta seeds*

TREATMENT	REPLICATION		MEAN
	I	II	
(hrs.)			
0	18	22	20
3	37	34	36
6	43	40	42
9	44	40	42
12	52	43	48
Mean	38.8	35.8	

hibitory chemicals are present in dormant seeds, the reaction reported by Ashbrook might have occurred in smoking rice seeds, with the produced chemicals reducing the dormancy period. The data for both wet and dry seeds were not precise enough to show reasonably consistent increase in germination percentages as duration of smoking was increased from 34 to 73 hours. With control II value as a guide, it was apparent that exposure to smoke for 34 hours was sufficient to increase the percentage of germination.

TABLE 4b.—*Germination percentage of smoked wet and dried newly harvested Peta seeds*

TREATMENT	WET			MEAN	DRY			MEAN	GENERAL MEAN
	Replication				Replication				
	I	II	III		I	II	III		
(hrs.)									
10	28	30	28	28.6	17	23	23	21.0	24.8
24	35	34	32	33.6	30	27	35	30.6	32.1
34	58	36	53	58.0	66	53	64	61.0	59.5
48	47	75	77	74.3	81	69	81	77.0	75.6
58	64	76	73	71.0	73	77	72	74.0	72.5
73	65	55	65	61.1	68	68	63	66.3	63.7
87	83	79	78	80.0	75	83	91	83.0	81.5
Control I [a]									2.0
Control II [a]									27.0

[a] Control I was placed in moist paper at the same time as the seeds from the shortest duration; control II, at the same time as the two longest durations.

There were no marked differences in germination between moisture conditions of seeds before smoking (table 4b), although corresponding values were consistently higher for the dry seeds.

TABLE 4c.—*Germination percentage of smoked newly harvested Peta seeds*

HOURS	REPLICATION			
	I	II	III	Mean
0	0	0	1	0.3
24	22	24	26	24.0
36	51	49	57	52.3
48	76	72	73	73.6
60	71	64	76	70.3
72	61	59	59	59.7
84	81	79	83	81.0
96	79	86	73	79.4
108	82	84	87	84.3
120	88	96	84	89.4
132	98	83	94	91.7
144	94	99	92	95.0
156	91	91	88	90.0
168	94	98	97	96.4

The effect of duration of exposure to smoke (table 4c) may be summarized as follows:

Duration (hours)	*Mean germination (per cent)*
0	0.3
24	24.0
36 to 72	64.0
84 to 108	81.6
120 to 168	92.5

At a 24-hour smoke treatment, there was a considerable increase in germination. Increase in germination percentage remained consistent as duration of exposure to smoke was increased. Exposure to smoke for 168 hours resulted in a germination percentage very close to 100, while the unsmoked Peta seeds gave only 0.3 per cent germination. Exposure for 84 hours was enough to increase the germination percentage to 81, and thus break the dormancy of the rice seeds.

Effect of Some Chemical Components of Smoke

Subjecting the seeds to a mixture of calcium carbide and formalin for 12 hours gave a germination of 83 per cent (table 5). The effect of some might have been simulated by this mixture. The reduction in germination due to longer exposure may be attributed to

TABLE 5.—*Germination percentage of dormant Peta seeds exposed to other sources of some components of smoke*

	LENGTH OF EXPOSURE (hrs.)			
	12	24	36	48
Control	4.6	4.6	4.6	4.6
Calcium Carbide and Formalin	83.0	78.7	68.6	42.3
Calcium Carbide and H_2O	13.0	20.0	12.0	3.3
Acetylene	6.0	5.0	19.3	6.6
Formalin	1.3	0	0	0
Calcium Carbide	19.6	13.0	7.3	7.0
Average	21.2	20.2	18.6	12.3

its toxic effect on the embryo. Formaldehyde (formalin)—acetylene alone could not cancel the rest period of rice. Calcium carbide alone or with water) tended to increase the percentage of germination when applied for 12 hours.

It is suggested that formalin-acetylene mixture be further tested to determine whether or not it is effective in breaking the dormancy period of rice.

DISCUSSION

The experiments on acid scarification with sulfuric acid, dehulling, soaking in hot water, and smoking all pointed to the presence of one or more chemicals in the seeds, most probably in the seed coat, in the pericarp, or in the hull, which inhibit germination. This inhibition, in turn, was partly or wholly neutralized by the different treatments.

Very recently, Mikkelsen [3] reported that certain chemicals, which include various essential oils, certain alkaloids, glucosides, and growth hormones present in the seed coat in various plants were demonstrated to inhibit germination. Identification of such chemicals present in the seed coat of rice should lead to a better understanding of the reaction that took place when the partially or totally effective treatments were applied and, consequently, to the discovery of the best way of breaking the dormancy period in certain rice varieties.

[3] Duane S. Mikkelsen, California Agriculture 14, p. 11 (June, 1960).

LITERATURE CITED

ASHBROOK, F. G. 1954. Butchering, processing and preservation of meat. New York: D. Van Nostrand Co., Inc.

BUENAVENTURA, M. R. 1956. Dormancy periods of promising rice varieties. Philippine Agriculturist **39**: 558-570.

BURK, L. G. 1957. Overcoming seed dormancy in *nicotiana*. Agron. Jour. **49** (8): 461-463.

EMPARAN, P. R. and H. M. TYSDAL. 1957. The effect of light and other factors on breaking the dormancy of guayule seed. Agron. Jour. **49** (1): 15-20.

GOODSELL, S. F. 1957. Germination of dormant sorghum seed. Agron. Jour. **49** (17): 387-391.

HARRINGTON, G. T. 1923. Forcing germination of freshly harvested wheat and other cereals. Jour. Agric. Res. **23**: 79-100.

JOHNSON, L. V. P. 1935. General preliminary studies in the physiology of delayed germination in *Avena fatua*. Canadian Jour. Res. (C) **13**: 283-300.

LLOYD, B. JENSEN. 1949. Meat and meat foods. New York: Ronald Press Co.

PETTET, A. E. and F. G. LANE. 1940. The chemical composition of wood smoke. Soc. Chem. Ind. Jour. **59**: 114-119.

RAMIAH, K. and M. B. V. N. RAO. 1953. Rice breeding and genetics. Indian Council Agric. Res. Sci. Mon. **19**.

SCHWENDIMAN. A. and H. L. SHANDS. 1943. Delayed germination or seed dormancy in Vicland oats. Agron. Jour. **35** (8): 681-689.

TOOLE, E. H. 1923. Progress report on the germination of dormant wheat. Proc. Assoc. Off. Seed Anal. N. America **14**: 80-83.

WHITCOMB, N. O. 1924. Dormancy of newly threshed grain. Proc. Assoc. Off. Seed Anal. N. America **16**: 28-33.

WILLIAMS, R. C. and B. C. WEBB. 1958. Seed moisture relationship and germination behavior of acid-scarified Bahiagrass seed. Agron. Jour. **50** (5): 235-237.

A CYTOGENETIC STUDY OF BUSH SITAO AND ITS PARENTAL TYPES [1]

E. T. Floresca, J. M. Capinpin, and J. V. Pancho

WITH SEVENTEEN TEXT FIGURES

The cytogenetic behavior of Bush Sitao (line No. 1), a true breeding hybrid between *Vigna sinensis* 'California Blackeye' and *V. sesquipedalis* 'Singapore', was compared with that of its parental forms. The hybrid and the parental forms showed both on the somatic and meiotic phases a basic chromosome number of 12, giving 2n = 24. Normal behavior of the chromosomes in the reduction division was observed in the hybrid, indicating close affinity and homology of the parental genomes.

The most commonly cultivated *Vigna* species in the United States and the Philippines are *V. sinensis* (L.) Savi (*paayap*) and *V. sesquipedalis* Fruw. (*sitao*). In recent years, these species, because of their agricultural and economic uses, have become very important. Plant breeders and geneticists, realizing this, are striving to improve them.

The hybridization and inheritance studies of *V. sinensis* in the country was pioneered by Capinpin (1935). Later Capinpin and Irabagon (1950) investigated the inheritance and crossing possibilities of different varieties of *V. sesquipedalis*. In the United States, Brittingham (1948) and Fennel (1948) have been successful in producing crosses between the bush and the viny species of *Vigna*.

Although *V. sinensis* (L.) Savi possesses the desirable bushy habit of growth, it has relatively poor table quality and short pods. In contrast, *V. sesquipedalis* Fruw. is viny but yields comparatively longer pods with better table quality. Petrache and York (1955)[2] successfully produced plants exhibiting the desired characteristics of both. Several lines of the hybrids which exhibited varying degrees of the desirable traits following the Mendelian laws of heredity were obtained. Acosta (1959), through intensive selection, succeeded in obtaining the desirable agronomic characters of both parental

[1] Central Experiment Station Contribution No. 2056.

[2] L. M. Petrache and T. L. York, "A study of hybrids obtained by crossing *Vigna sinensis* and *V. sinensis* var. *sesquipedalis*," 1956. Unpublished.

types. From among these lines, Sitao (line No. 1) was selected as the most desirable.

The object of the present investigation is to interpret cytogenetically the apparent fertility and true breeding quality of Bush Sitao by studying: a) the chromosome counts of the parental types and Bush Sitao itself, and b) the genome constitution based on cytological observation.

The work was conducted from July, 1959 to February, 1960, in the Cytogenetic Laboratory and in the field lots of the Department of Agricultural Botany, U.P. College of Agriculture.

MATERIALS AND METHODS

Cytological Technique

Permanent preparation from root-tips. Seeds of Bush Sitao (line No. 1), *Vigna sinensis* 'California Blackeye', and *V. sesquipedalis* 'Singapore'[3] were germinated in seed boxes filled with Palawan white sand. After two to three days, root-tips of the bean seeds were collected. For preliminary study, these were collected at 6 a.m., 8 a.m., 10 a.m., 12 noon, 2 p.m., 4 p.m., 10 p.m., and 12 midnight, and fixed in CRAF's fixative. Dehydration, clearing, and staining were done according to the method of Randolph (1940). Paraffin sections were microtomed at 12/u. None of these gave the desired number of mitotic figures but later collections made at 2 a.m. gave satisfactory results.

Observations of the somatic chromosome morphology and chromosome counts were based on the best prepared slides. Camera lucida drawings were made.

Smear preparation of the pollen mother cells. Flower buds were collected from 6 a.m. to 6 p.m. at two-hour intervals from each of the parental types and the Bush Sitao. Preliminary examination of the different sizes were prepared according to the technique described by Smith (1947). The method was modified by steaming the preparation for about 30 seconds instead of passing it over an alcohol flame to dissolve the matrix away. This left the chromonemata intact on the slide, thus spreading the chromosomes and making them more visible.

[3] Seed materials were obtained from Mr. Jose R. Deanon Jr., of the Vegetable Section, Department of Agronomy.

Chromosome counts and observation on the meiotic pairings were based on the smear preparations exhibiting clear chromosome configuration. Meiotic stages were obtained from pollen mother cells (PMC).

Camera lucida drawings were made at a magnification of ca. 1,200 and reduced in reproduction to ca. 600. Herbarium specimens and preserved flower buds of the materials studied were prepared and deposited in the College of Agriculture Herbarium for future reference.

Hybridization Technique

To test the compatibility and fertility of the different materials used, differential plantings were made to synchronize the following periods of the plants for breeding work.

Emasculation and pollination. As soon as enough flower buds had appeared, emasculation was done from 4 to 6 p.m. and pollination, from 6 to 8 the next morning, following the method of Capinpin and Irabagon (1950).

Backcrossing technique. Reciprocal backcrosses were made between the parental types and the hybrid.

Successfully cross-pollinated flowers were allowed to mature. The seeds of the cross-pollinated pods were harvested and then planted in separate rows for each pod. The seed of the two *Vigna* species and Bush Sitao were also planted in separate plots.

Genetical characteristics of the backcross of the progenies were noted.

RESULTS AND DISCUSSION

The somatic chromosomes. Somatic chromosome counts were made with great difficulty owing to the small size of the chromosomes in both *V. sinensis* 'California Blackeye' and *V. sesquipedalis* 'Singapore' and Bush Sitao (line No. 1). This also made impractical a detailed differentiation of morphological characteristic of the chromosomes among the three plants. It was possible, however, to observe that there was no appreciable difference in the absolute sizes of the chromosomes among the species. Careful examination of the genomes of all the plants exhibited baculiform or rod-shaped chromosome forms. Somatic counts which demonstrated the diploid nature

(2n = 24) (fig. 6, 9, and 11) for Bush Sitao and its parental types agree with previous reports on *V. sinensis* and *V. sesquipedalis* by Kawakami (1930) who worked on the chromosome numbers of the family Leguminosae. Senn (1938), as cited by Roy and Richaria (1948), also found the chromosome number of 2n = 24 for both *V. sinensis* and *sesquipedalis*. However, Darlington and Wylie (1956) citing Karpechenko (1924), gave chromosome numbers of 2n = 22 and 24 for *V. sinensis*.

The meiotic chromosomes. It was observed that the flower buds where the sporocytes were undergoing meiosis were between four and six millimeters. Meiotic divisions were noted to occur actively on the first four initiated buds collected between 6 and 8 a.m.

The meiotic configurations of all PMC smears of Bush Sitao and its parental types appeared to be regular and normal (fig. 1 to 5, 7, 8, 10, 12 to 15). There was an apparent absence of chromosomal irregularities such as occurrence or rings, multivalents, and univalents.

The tetrads of Bush Sitao (line No. 1) were regular in having four cells (fig. 16). The pollen grains which were also examined showed well-filled grains (fig. 17).

The degree of chromosome homology, vigor and pollen fertility in Bush Sitao demonstrates that *V. sinensis* is closely related and homologous to those of *V. sesquipedalis*.

Backcrossing technique. Success or failure of artificial pollination was similar to that observed by Capinpin (1935). Futile fertilization was indicated by the falling of the flowers as early as 12 hours after fertilization. Generally, after a lapse of 48 hours after pollination, a small green structure of the pod became evident, indicating the successful setting of the pods.

Tables 1, 2, and 3 show the results of backcrossing the hybrid to either of the two parents. Pollen of Bush Sitao used on both *V. sinensis* and *V. sesquipedalis* produced seed sets (tables 1 and 2). When the pollen of *V. sinensis* was used on Bush Sitao, extremely low pod set was obtained (table 3). These results, however, still indicate low pod setting. The same result in difficulty in pod setting was encountered by Capinpin (1935), Roy and Richaria (1948), Hawthorne (1949), and Petrache and York (1956). These researchers attribute the low percentage of pod setting partly to unfavorable

EXPLANATION OF FIGURES 1-15

Fig. 1-15.—Camera lucida drawings of the sporocytes (PMC) and root tip cells of Bush Sitao and its parental types. Bush Sitao (line No. 1): fig. 1.—Prometaphase 1, fig. 2.—Anaphase 1, fig. 3.—Telophase 1, fig. 5.—Metaphase 1, fig. 6.—Somatic chromosomes in root tip cells (2n-24); *Vigna sinensis* 'California Blackeye': fig. 4.—Prometaphase 1, fig. 7.—Metaphase 1, fig. 8.—Anaphase 1, fig. 9.—Somatic chromosomes in root tip cells (2n-24), fig. 10.—Telophase 1; *Vigna sesquipedalis* 'Singapore': fig. 11.—Somatic chromosomes in root tip cells (2n-24), fig. 12.—Anaphase 1, fig. 13.—Metaphase 1, fig. 14.—Prometaphase 1, and fig. 15.—Telophase 1.

climatic and weather conditions such as cooler days and unexpected rainfall. Since table 3 shows an exceedingly low percentage of pod set of 2.5 per cent, such discrepancy could be due to some types of incompatibility.

Fig. 16.—Photomicrograph of a regular tetrad of four cells of Bush Sitao.

Fig. 17.—Photomicrograph of well-filled pollen grains of Bush Sitao.

TABLE 1.—*Results of backcrossing the Bush Sitao to Vigna sesquipedalis, 'Singapore'* (*Singapore* × *Bush Sitao*)

DATE POLLINATED	NO. OF FLOWERS POLLINATED	NO. OF POD SET	PERCENTAGE OF POD SETTING
Dec. 2, 1959	5	0	00.00
" 3, "	5	1	20.00
" 11, "	8	2	25.00
" 14, "	9	3	33.00
" 15, "	10	3	30.00
Total	37	9	108.00
Average	—	—	21.60

TABLE 2.—*Results of backcrossing the Bush Sitao to Vigna sinensis 'California Blackeye'* (*California Blackeye* × *Bush Sitao*)

DATE POLLINATED	NO. OF FLOWERS POLLINATED	NO. OF POD SET	PERCENTAGE OF POD SETTING
Nov. 24, 1959	5	0	00.00
" 25, "	5	1	20.00
" 26, "	10	2	20.00
" 30, "	10	3	30.00
Dec. 15, "	5	2	40.00
Total	35	8	110.00
Average	—	—	22.00

TABLE 3.—*Results of backcrossing the Vigna sinensis 'California Blackeye' to the Bush Sitao* (*Bush Sitao* × *California Blackeye*)

DATE POLLINATED	NO. OF FLOWERS POLLINATED	NO. OF POD SET	PERCENTAGE OF POD SETTING
Nov. 27, 1959	5	0	00.00
" 29, "	5	0	00.00
Dec. 2, "	8	1	12.50
" 3, "	5	0	00.00
" 4, "	5	0	00.00
Total	28	1	12.50
Average	—	—	2.50

It is possible that the pod set in table 3 was due to selfing. This presumption could be maintained since only two seeds, instead of more than two as in a normal pod, were formed. Unfortunately, no definite conclusion could be made since the single pod obtained was eaten before it could be harvested.

All the backcrossed progenies exhibited phenotypical characters similar to those shown by the F_1 generation obtained by Petrache and York (1956). It was observed that the bushy habit of growth was dominant over the viny habit. The desirable pod character of *V. sesquipedalis* was also manifested in the backcrossed progenies.

CONCLUSION

The results obtained, namely, that the hybrid shows normal meiotic pairing and has the same chromosome number as its parental forms, show that *Vigna sinensis* 'California Blackeye' and *V. sesquipedalis* 'Singapore' have similar genome complements. Added to this cytological evidence, the fact that the hybrid does not exhibit any self-incompatibility and produces fertile seeds indicate that Bush Sitao (line No. 1) is a hybrid of true fertility and of good breeding quality.

LITERATURE CITED

ACOSTA, J. C. and L. M. PETRACHE. 1960. The transfer of the bushy character from cowpea (*Vigna sinensis* [Linn.] Savi) to Sitao (*Vigna sesquipedalis* Fruw.). Philippine Agriculturist **43** (9): 535-547.

BRITTINGHAM, W. H. 1948. Inheritance of date pod maturity, pod length, seed shape and size in the southern pea, *Vigna sinensis*. Proc. Amer. Soc. Hort. Sci. **56**: 381-388.

CAPINPIN, J. M. 1935. A genetic study of certain characteristics in varietal hybridization of cowpea. Philippine Jour. Sci. **57**: 149-165.

———— and T. A. IRABAGON. 1950. A genetic study of pod and seed character in *Vigna*. Philippine Agriculturist **33**: 267-277.

DARLINGTON, C. D. and A. P. WYLIE. 1956. Chromosome atlas of flowering plants. 2nd ed. xix + 519 p. London: Allen and Unwin, Ltd.

FENNEL, J. H. 1948. New cowpea resistant to mildew. Jour. Hered. **39**: 275-279.

HAWTHORNE, P. L. 1949. Breeding and improvement of edible cowpea. Proc. Amer. Soc. Hort. Sci. **42**: 562-564.

KAWAKAMI, J. 1930. Chromosome relationship in Leguminosae. Bot. Mag. Tokyo **44**: 319-327.

RANDOLPH, L. F. 1940. Card mounts for handling root-tips in the paraffin method. Stain Tech. **15**: 45-48.

ROY, R. S. and R. H. RICHARIA. 1948. Breeding and inheritance studies on cowpea, *Vigna sinensis*. Jour. Amer. Soc. Agron. **40**: 479-489.

SHARP, W. L. 1943. Fundamentals of cytology. 1st ed. x + 270 p. New York and London: McGraw-Hill Book Co., Inc.

SMITH, L. 1947. The aceto-carmine smear technique. Stain Tech. **22**: 17-31.

MUTANTS ISOLATED FROM X_1 AND X_2 GENERATION OF RICE (*O. SATIVA*)[1]

FILOMENA F. CAMPOS and LUCILA G. ESPIRITU

WITH SIX TEXT FIGURES

Several mutants were isolated from the X_1 and X_2 generation. Among them were a high tillering mutant, albino and pigmented plants, and dwarf progenies. A morphogenetic description of each type was made together with data on the frequency of their occurrence. Observations on the important agronomic characters were also made.

Mutants described in this work were isolated from unhulled and hulled dormant seeds exposed to X-ray dosages of 2 kr, 5 kr, 10 kr, 20 kr, and 50 kr and from seeds harvested from the X_1 generation.

This investigation includes a morphogenetic description of the mutants, the frequency of their appearance, and analyses of their more important agronomic characteristics.

MUTANT WITH SEGREGATING ENDOSPERM AND HULL COLOR

Among the X_1 progenies, a particular mutant was isolated from the unhulled lot at 2 kr and described as a plant with dwarfish, bushy-type growth in its early vegetative stage (up to one month old), light green and narrow leaves and profuse number of tillers. The growth was later enhanced and at harvest time, the plant was even taller than the control. The harvested grains showed a distinct segregation of hull and endosperm color; the white endosperm was covered by a yellowish hull and the red endosperm, by a dull brownish-yellow hull (Campos, *et al.*, 1959).[2]

The seeds were all collected and then planted separately. Four hundred seeds representing each type were sown in seedboxes on August 1, 1959, and transplanted in the field two weeks later. All important agronomic characters were observed during early and later growth. Statistical comparisons of the performance of white- and red-seeded plants were made.

During the vegetative stage, the red-seeded plants showed the same habit of growth as the "mother" plant while the white-seeded

[1] Central Experiment Station Contribution No. 2057 . Rice and Corn Project No. 15.

[2] F. F. Campos, *et al.*, *Philippine Agriculturist* **43**, 200 (1959).

plants remained as normal ones (fig. 1). The tillers were exceptionally numerous in the red-seeded plants and normal in number in the white-seeded ones (fig. 2). Statistically, productive tillers among red-seeded plants were significantly higher in percentage than among the white-seeded ones. No significant difference in plant height, percentage of filled grains, panicle length, and weight of 100 grains existed. However, data on straw weight indicated that the red-seeded plants were significantly heavier than the white-seeded ones.

An observation similar to that in the mother plant during the first generation was seen among the red-seeded plants. They matured 20 days later (harvested on January 4, 1960) than the white-seeded plants (harvested on December 15, 1959).

No segregation of hull and endosperm color was observed among the surviving plants of these types of seeds. Both bred true to type for grain characteristics. The seeds from the red series were quite smaller than the white seeds. This difference was, however, not significant.

Among the white-seeded group, seemingly dwarf plants constituted 3.3 per cent of the total surviving plants. No such dwarfness was noticed among the red-seeded plants.

ALBINO AND PIGMENTED PLANTS

The mutant seedling characters were mostly chlorophyll-deficient plants (fig. 3a). These were observed as early as four days from sowing. A few of them survived up to maturity although they were weak and chlorotic. The majority or 73 per cent of the mutants were albinos. This type of mutants was found in 2, 20, and 50 kr. About 14 per cent were "green-striped" which developed into solid green a month after planting. The rest consisted of plants with pigmented stems.

Among the dosages, 50 kr with unhulled treatment produced the highest frequency of albino seedlings (64 per cent). Of these, only one plant survived up to maturity. The chlorotic condition persisted only for seven days, then the leaves turned to light green (fig. 3b). This plant produced seven tillers, six of which were productive. The panicles showed a striking feature of the grains: majority of them exhibited an underdeveloped endosperm enclosed in a partially opened hull (fig. 3c). Viability of the mutant plants ranged from 14 to 21 days.

Fig. 1.—Mutant plants isolated from X_2 generation hulled rice seeds (2 kr) with segregated endosperm color showing the habit of growth one month after planting. a—seedlings from white seeds; b—seedlings from red seeds; and c—control.

Fig. 2.—Profusely tillering X_2 mutants from first generation irradiated hulled seeds with segregated endosperm color treated at 2 kr (four months old). From left to right: control; red-seeded mutant; and white-seeded mutant.

Fig. 3a.—Albino plant isolated from 50 kr lot.
3b.—The same albino plant turned green after one month.

Six out of the 13 green-striped plants which were obtained from 20 kr-treated plants (unhulled) reached a maturity of 130 days while others survived for only 33 days. The stripes shown by the plants disappeared 18 days after sowing, subsequently turning yellow-green and then to solid green. No striking characteristics were observed on these plants, although tillering was relatively lower than the control.

The only characteristic feature which persisted to maturity among the different mutants was the pigmented stem (fig. 4a). Frequency of this mutant type follows a consistent value for 5, 10, and 50 kr (about 30 per cent of the total pigmented plants). A differential intensity of pigmentation was observed among the dosage lots,

Fig. 3c.—Typical panicle obtained from the albino plant which turned green after one month. Note that some of the grains are unfilled and partially open.

that is, 2 kr lots were less pigmented and 5 kr lots were the darkest. After 132 days, the plants were harvested with the average productive tillers of four.

Fig. 4a.—Rice seedling one month after planting showing the purplish pigmentation on the stem immediately above the base.

Among the pigmented plants, a distinct pigmentation was noticed in the grains (fig. 4b). They produced bluish-purple grains sporting purple apiculus resembling the color found in Fortuna, one of the parents of the variety under study.

Fig. 4b.—Pigmentation of grains with distinct purple apiculus from panicle of a pigmented plant.

THE DWARF PLANTS

As early as one month after transplanting was done in the field, dwarf plants could already be distinguished (fig. 5). The majority of them possessed green, short, narrow leaves and erect stems. Some

Fig. 5.—Height of dwarf plants isolated from first generation unhulled rice seeds after a month from planting. From left to right: dwarf plant treated at 5 kr; dwarf plant treated at 20 kr; dwarf plant treated at 50 kr; and control.

had short but broad leaves and exhibited the bushy type of growth. Thirty-eight dwarf plants were transferred in pots and brought in the screenhouse for closer observation. Of the total number of this type of mutants, about 14 which were obtained from lots treated at 2 kr, produced an average height of 79 centimeters. About 31 per cent were found in 10 kr lots with a mean height of 87 centimeters.

The height of these dwarf plants ranged from 64 to 11 centimeters, the former height being found in a plant at 50 kr (fig. 6).

Fig. 6.—Dwarf mutants from first generation irradiated seeds at maturity. From left to right: control, plant at 2 kr; plant at 10 kr; plant at 20 kr; and mutant treated at 50 kr.

Very few of these mutants produced a large number of tillers. The highest number which was found in 20 kr was 26. On the average, however, the number exceeded that of the control.

The average percentage of filled grain was 76-72 per cent, resulting in a difference of 12.58 per cent from the control.

THE SPECTROGRAPHIC ANALYSIS OF TRACE ELEMENTS IN SOME PHILIPPINE SOILS [1]

SIMEON A. CUYSON, AURORA T. VIOLANDA-CALO, and ROGELIO R. COVAR [2]

WITH FOUR TEXT FIGURES

A composite sample of each of the 10 soil types were analyzed for the trace elements B, Ba, Co, Cr, Cd, Cu, Mn, Mo, Ni, Sr, and Zn. All the soil types were found to contain B, Cu, Mn, and Ni in total quantities greater than the sensitivity of these elements found in the standards. Chromium was found in two soil types; one soil type contained about 90 ppm. Three soil types contained zinc at concentrations above the established sensitivity limit. For Co, Ba, Cd, and Mo, the intensity of the spectral lines produced were too low for quantitative estimation with the use of a densitometer.

Conventional methods of plant and soil analyses are rapidly being supplemented with the faster and often more accurate instrumental procedures. One procedure uses a common instrument called the emission spectrograph.

In the past few years, the use of the spectrographic methods of analysis on almost all types of materials from metallic alloys to biological tissues has been extensive. The method saves time and produces a permanent record on the photographic plate. For most elements, an accuracy exceeding five per cent is attainable. Under controlled conditions, more than one or two mineral elements can be quickly determined simultaneously.

The spectrograph is especially useful for semi-quantitative exploratory work. The more accurate quantitative results could serve as a measure of the accuracy of the other methods of analysis. It should be remembered, however, that the spectrograph is not the answer to all the problems of the analyst.

The analysis of materials by the use of a spectrograph is based on the fact that each element yields a different characteristic spectrum which identifies it clearly and definitely. These elements which

[1] Central Experiment Station Contribution No. 2058.

[2] Grateful acknowledgment is due the Director, Bureau of Soil Conservation for giving us the permission to use the Bureau's facilities; and Messrs. Feliciano M. Lapid and Apolinario de Leon, also of the said bureau, for their assistance.

emit radiation with 2,000-10,000 angstrom units (A) can be analyzed by the spectrographic method.

The direct-current arc is the most common and convenient excitation source used in the spectrographic analysis of soils. It advantageously gives a high amperage and consequently, the higher temperature necessary for the excitation of soil samples and other agricultural materials. For the determination of some elements, however, the more accurate and conventional wet chemical methods are more advisable. Examples of these are Si, Al, and Fe. The same is true for such elements as Ca, Mg, Na, K, Ti, and even Mn to a lesser degree. Unlike the case of major elements, analysis of the total content of trace elements is significant.

This study was conducted to determine spectrographically the presence and total amounts of the trace constituents Ba, B, Cd, Cr, Co, Cu, Mn, Mo, Ni, Sr, and Zn in some Philippine soils. It was done from July, 1958, to June, 1959 in the Department of Agricultural Chemistry, U.P. College of Agriculture and the Bureau of Soil Conservation, Manila.

Spectrochemical methods of analysis of plants and soils have been in use in a number of agricultural research laboratories.

Lundegardh (1951) devised flame and other spectrographic techniques which are well adapted to the determination of the alkali and alkaline earth metals in solution at the levels commonly met in agricultural investigations.

The ASTM Committee on Emmission Spectroscopy suggested a number of tentative methods and procedures in connection with the spectrographic analysis of metals and other refractory materials with the use of both direct current arc and spark sources of excitation.

For most trace elements, flame or spark excitation is not adequate and the more sensitive arc excitation must be employed. Mitchell (1955) introduced a technique whereby a powder sample is filled into a boring in a carbon electrode and excited by the high temperature produced when a direct current arc is struck between the filled electrode and a solid upper electrode. Other methods have been reviewed in other publications by Mitchell (1947, 1948, 1957).

Erwin (1950) analyzed plants and soil samples with the use of the pellet technique. Powdered soil samples were made into pellets by means of a press capable of delivering 80,000 pounds per square

inch. For arcing, the pellets were placed in 5/16" cavities formed by a special tool in the carbon electrode. The sample was excited by a direct current source. Ballard (1937, 1940) described a semi-quantitative method for soils using the normal direct current arc technique. A finely ground sample from one mg. to 50 mg. of materials was placed in a conical boring (diameter: depth ratio of 2:1 for small samples to 1:2 for large samples) in a graphite or copper electrode and burnt at the anode which gave a steadier arc at 4-10 amperes.

Specht (1954) introduced a coordination of the many techniques which have already been used in several laboratories. The powdered material is mixed with spectrographic buffer material and then placed in the crater of a paraffined carbon electrode. The sample is treated with concentrated HCl, then dried in an oven and later on excited by the use of a direct current arc with 10-20 ampere current.

Rogers *et al.* (1939) used a small portion of a homogenized soil or plant material (about 10 mg.) and volatilized it in the anode of a 220-volt direct-current arc using a current of 9-10 amperes.

MATERIALS AND METHODS

The materials used were:

1. A composite sample for each of the 10 soil types indicated below, taken from the stocks of the Departments of Soils and Agricultural Chemistry:

SOIL SAMPLE	SOIL SERIES	SOURCES	DEPTH IN INCHES
1	Guimbalaon	Bacolod City	48–54
2	Syenite (Rotten rock)	Jamboree Site, College	108–125
3	Unclassified	P-12 varietal	0– 6
4	Umingan	Panay	0– 6
5	Guimbalaon	Bacolod City	24– 36
6	Unclassified	Block X-a	0– 6
7	Adtuyon	Del Monte, Bukidnon	0– 6
8	Unclassified	College	0– 6.5
9	Lipa Clay Loam	Batangas	0– 6
10	Calumpang Clay Loam	Batangas	0– 6

2. Bausch and Lomb Large Littrow Spectrograph of the Bureau of Soil Conservation.

3. A step sector.

4. An American Research Laboratory Densitometer (Model 2250).

5. Photographic chemicals.

6. Photographic films — 35 mm. nonperforated fine-grain positive Kodak P402.

7. Bausch and Lomb Electrode Cutter and National Brand Spectroscopic Carbon Electrodes, 1.5″ x 3/16″.

Standards for Ba, B, Cd, Cr, Co, Cu, Mn, Mo, Ni, Sr, and Zn were prepared at concentrations of 0.1, 0.03, 0.01, 0.003, 0.001, 0.0003, and 0.0001 per cent. They were grouped into two for convenience.

Standard Group A

ELEMENT	COMPOUND	WEIGHT OF COMPOUND IN MG. PER 10,000 MG. OF MIXTURE IN SOIL BASE [a]
Barium (Ba)	$BaSO_4$	17.0
Boron (B)	H_3BO_3	57.1
Cadmium (Cd)	CdO	11.4
Chromium (Cr)	$K_2Cr_2O_7$	29.2
Cobalt (Co)	$CoSO_4$	26.8
Copper (Cu)	$Cu(COOCH_3)_2$	22.3

Standard Group B

ELEMENT	COMPOUND	WEIGHT OF COMPOUND IN MG. PER 10,000 MG. OF MIXTURE IN SOIL BASE [a]
Manganese (Mn)	Mn_2O_3	14.4
Molybdenum (Mo)	MoO_3	17.6
Nickel (Ni)	$Ni(NO_3)_2.6H_2O$	4.1
Strontium (Sr)	SrO	12.0
Zinc (Zn)	ZnO	12.4

[a] The weights of the compounds given above give a final concentration of 0.1 per cent of each trace element in the soil base mixture.

All the weighted compounds of 0.1 per cent for each group were mixed thoroughly in an agate mortar to insure uniform composition of the mixture.

A synthetic soil base having the following composition was prepared from chemically pure reagents. This soil base served as matrix:

Fe_2O_3	1 part
Al_2O_3	2 parts
BiO_2	12 parts
CaO	¼ part
MgO	¼ part
K_2O	½ part

These compounds were weighed accurately by parts, mixed thoroughly and sintered overnight in an electric furnace at about 128°C.

To the total weight in mg. of the 0.1 per cent mixture in each group was added a weight of the soil base to make a total of 10,000 mg. mixture in soil base. For example, the total weight of the 0.1 per cent mixture in Group A is 163.8 mg. To this was added 9.8362 gm. of the soil base, making a total of 10.0 gm, of 0.1 per cent mixture in soil base.

Lower concentrations of 0.03, 0.01, 0.003, 0.001, 0.0003, and 0.0001 per cent were prepared by dilution with soil base.

Finally, after all dilutions had been made, carbon powder was added to produce a 1:1 ratio. Carbon served as background. In all cases, contamination was avoided as much as possible.

Preparation of electrodes. A Bausch and Lomb Electrode Cutter was used. Carbon electrodes were cut and shaped into upper and lower electrodes (fig. 1). The lower electrodes were used as anodes so as to get a higher temperature of excitation.

Preparation of samples. The soils were air-dried on trays. These were ignited at 450°C. to destroy organic matter which could interfere with the burn.

After ignition, the soils were pulverized in an agate mortar to a fine powder passing through a 2-cm. sieve. These were then weighed and mixed with graphite (1:1). The lower electrodes (anodes) were then filled with this mixture.

Excitation procedure. Before all exposures were made, the sample-filled electrodes were fired in the Bunsen flame to dry. This prevented puffing out when they were exposed to a higher temperature with a direct current source.

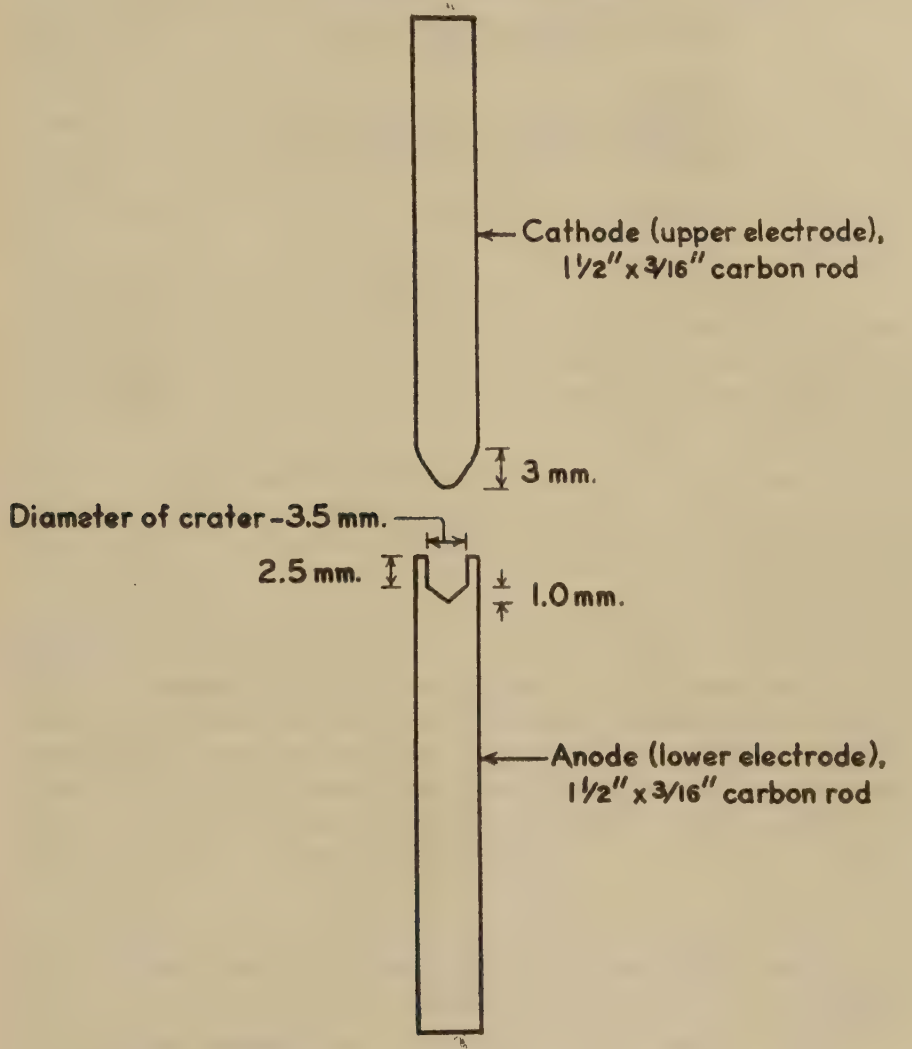

Fig. 1.—Illustration of electrodes used. (Scale: 2x)

To determine the sector that would give the clearest spectra, exposures were made using 0, ⅛, ¼, ½, ¾, and 1 sectors of a one-step sector. The slit width was placed at 40 *u;* a direct-current arc source was used. Position 5 (wavelength range, 2468-3392 A°) was selected.

The standards and the soil samples were exposed in triplicate, each on a different film, employing the following spectrographic conditions:

Excitation source-direct-current arc
(220 volts)
Amperage ..... 10 amperes
Exposure ..... 60 seconds
Slit width ..... 40 *u*

The films were then photographically processed, using standardized conditions.

The standard lines were then identified and selected by comparison with the quantitative standards of the elements.[3] This was done by looking for those lines which could be used as reference lines. One or two reference lines like those of Si or Mg served this purpose.

The unknown lines were then identified with reference to those of the standards. The percentages of light transmitted by chosen spectral lines of both standards and unknowns were measured with the densitometer.

Analytical working curves were drawn on a semi-logarithmic paper (4 cycles x 70 divisions) for each element. These curves were constructed by plotting the concentrations of given elements in their respective standardized solutions against the percentage light transmission of the spectral lines produced by the corresponding elements as read from the ARL Densitometer. From the analytical working curves, the quantity of each element in the soil samples were read.

RESULTS AND DISCUSSION

The spectral range from 2600 A to 3393 A was studied in the analyses of the different soil samples.

Table 1 shows the wavelengths of the elements studied. Although more than one line was detected to establish the identity of some elements like boron, chromium, copper, and manganese, only one specific line sufficed for each quantitative estimation. It was found out that the sensitivities of the different elements in the standards varied. The sensitivity limits of 0.0001 per cent (1 ppm) for boron, copper, and manganese, 0.001 per cent (10 ppm) for nickel and molybdenum, and 0.01 per cent (100 ppm) for chromium, cobalt,

[3] Standard method for preparation of qualitative standards using $NaNO_3$ matrix, employed with some modifications at the Bureau of Soil Conservation, Manila.

barium, cadmium, and zinc were observed. Strontium was not detected.

TABLE 1.—*Wavelengths of elements studied*

ELEMENT	WAVELENGTH (°A)
Boron (B)	2497.7
Barium (Ba)	3071.6
Cadmium (Cd)	3261.1
Copper (Cu)	3273.9
Cobalt (Co)	3044.0
Chromium (Cr)	3015.2
Manganese (Mn)	2801.1
Molybdenum (Mo)	3170.3
Nickel (Ni)	3050.8
Zinc (Zn)	3345.0

Comparison of the standard lines with that of the carbon spectrum showed the presence of a small amount of boron in the latter. In the soil base mixture, the presence of copper and manganese was detected.

The analytical working curves established from the standard solutions are shown in figures 2, 3, and 4. Each experimental point on which the curves were based represented the average of three determinations photographed on three individual films. In the soil samples, only readings for boron, chromium, copper, manganese, nickel, and zinc were obtained because the sensitivities of the other elements were lower than those established in the standards.

Tables 2 and 3 show respectively the transmission readings of the standards and soil samples obtained from an ARL Densitometer. The concentrations of each element as read from the analytical working curves are shown in table 4.

Boron. The boron contents of the different soil samples did not vary greatly. The boron values shown in table 4 represent corrected values for the element. The concentration in the soil samples ranged from 2.5 (sample 5) to 9.7 (sample 3) ppm.

Chromium. Only samples 4 and 6 were found to contain appreciably detectable amounts of chromium.

Copper. Of all the elements studied, copper was the least difficult to analyze. Sample 2 showed a very small amount of copper

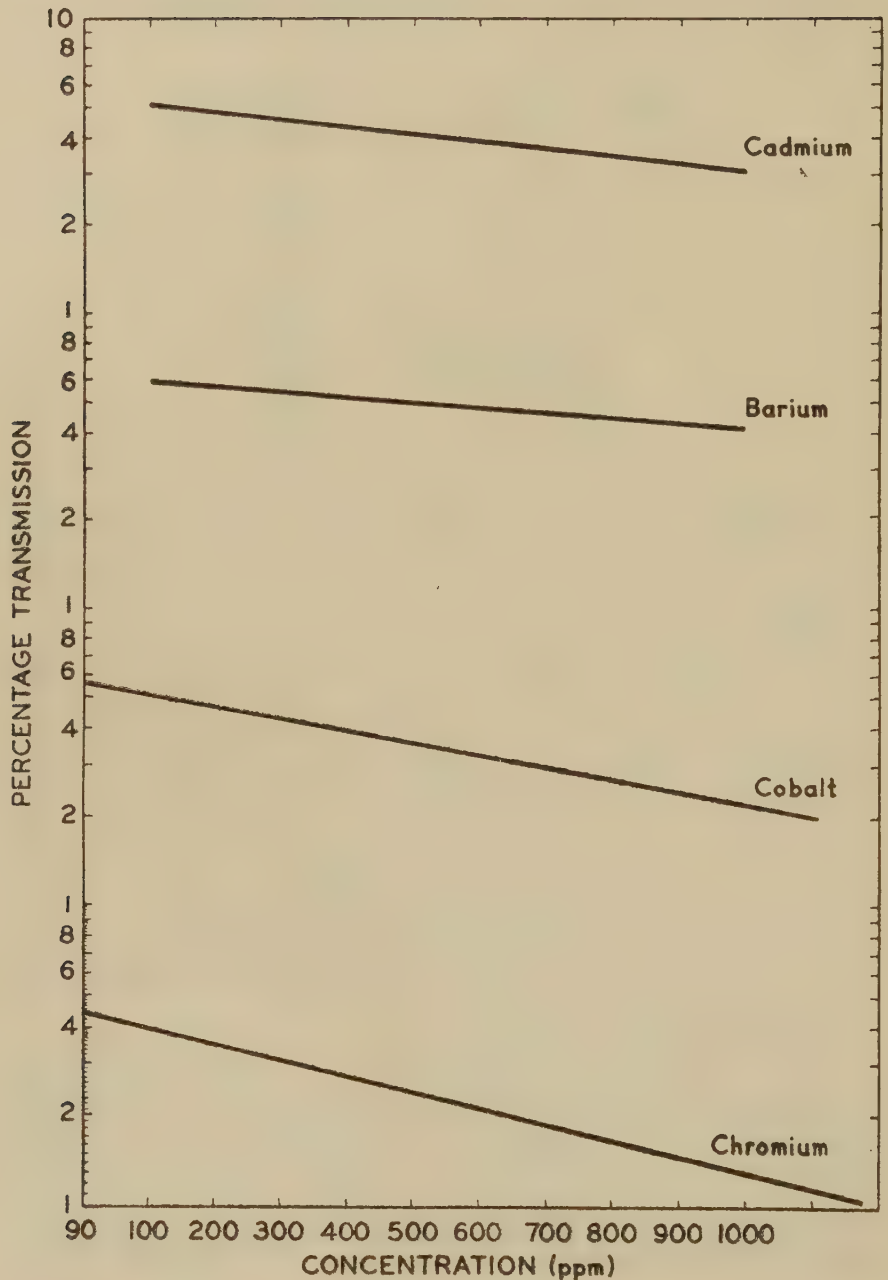

Fig. 2.—Analytical working curves for Cd, Ba, Co, and Cr.

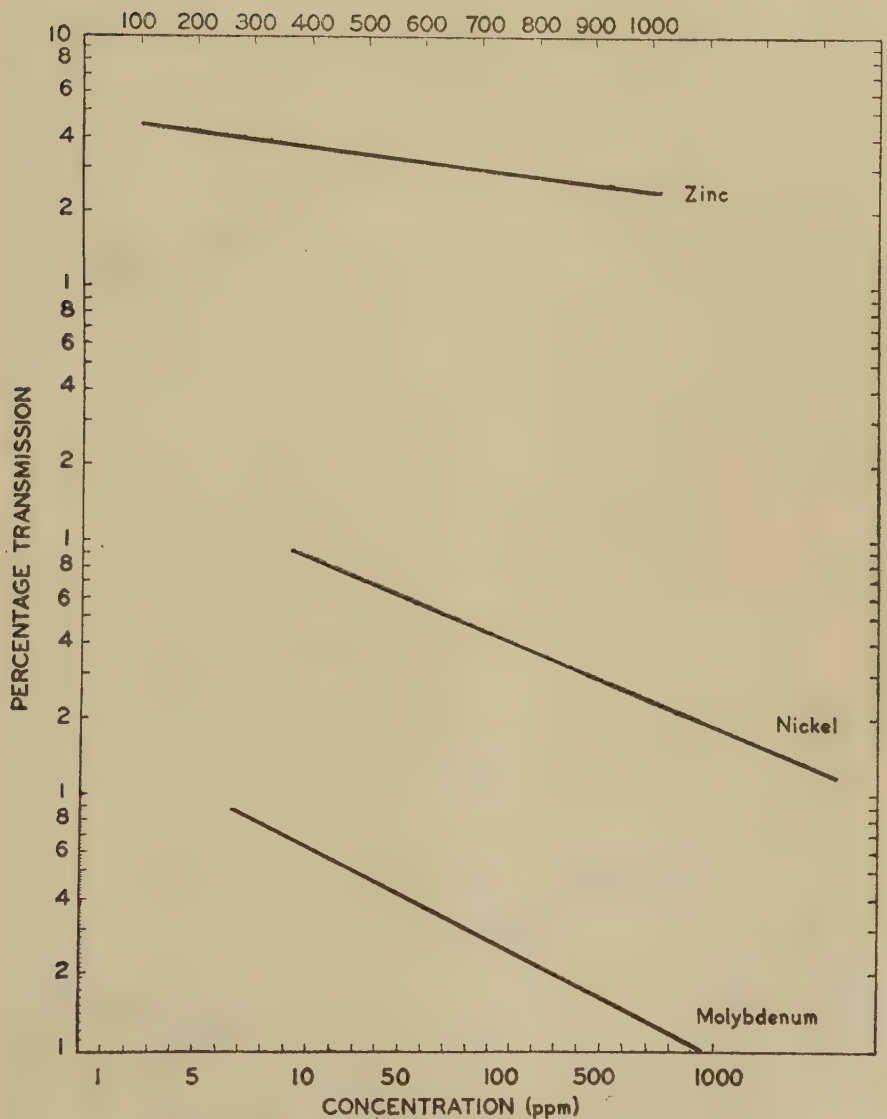

Fig. 3.—Analytical working curves for Zn, Ni, and Mo.

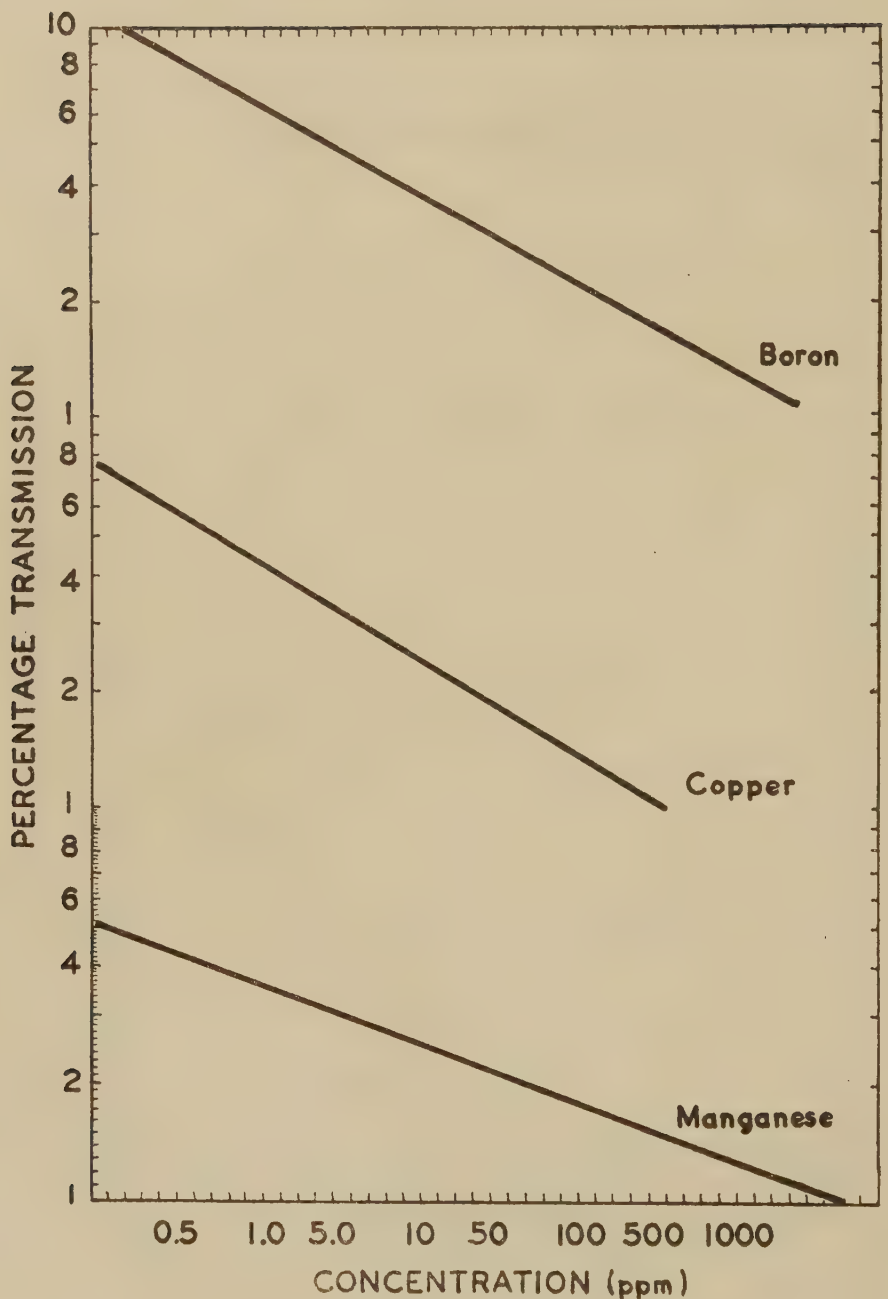

Fig. 4.—Analytical working curves for B, Cu, and Mn.

TABLE 2.—*Percentage transmission readings of standards* [a]

ELEMENT	CONCENTRATION IN P.P.M.							SOIL BASE	CARBON
	1000	300	100	30	10	3	1		
				Group A					
Boron (B)	15.5	19.0	22.0	33.0	38.0	52.5	62.0	—	68
Barium (Ba)	41.5	56.2	58.2	—	—	—	—	—	—
Cadmium (Cd)	31.0	45.0	52.2	—	—	—	—	—	—
Copper (Cu)	0.1	1.8	3.9	10.8	15.7	26.0	29.0	31.5	—
Cobalt (Co)	22.0	42.2	49.7	—	—	—	—	—	—
Chromium (Cr)	13.7	30.5	40.2	—	—	—	—	—	—
				Group B					
Manganese (Mn)	3.0	5.7	7.3	11.2	14.0	24.0	26.0	37.0	—
Molybdenum (Mo)	10.0	20.7	48.2	54.7	61.2	—	—	—	—
Nickel (Ni)	9.0	37.5	56.0	67.7	72.0	—	—	—	—
Zinc (Zn)	25.5	37.0	44.2	—	—	—	—	—	—

[a] Average of three determinations.

TABLE 3.—*Percentage transmission of ten soil samples* [a]

SOIL TYPE NUMBER	ELEMENT					
	Boron	Chromium	Copper	Manganese	Nickel	Zinc
1	48.0	—	4.3	7.8	18.7	—
2	50.0	—	27.0	5.6	22.7	—
3	34.0	—	2.4	5.2	32.7	—
4	47.0	23.5	6.3	8.0	43.7	—
5	52.0	—	4.0	5.3	21.8	—
6	36.0	43.3	3.3	4.1	30.0	35.0
7	37.0	—	4.2	4.0	28.5	27.0
8	49.5	—	2.5	5.0	31.0	—
9	48.0	—	3.4	5.8	33.8	32.0
10	35.0	—	4.5	6.0	47.5	—

[a] Average of three determinations.

TABLE 4.—*Concentrations of each element in parts per million*

SOIL TYPE NUMBER	ELEMENT					
	Boron	Chromium	Copper	Manganese	Nickel	Zinc
1	4.0	[a]	86.0	119.9	440.0	[b]
2	3.2	[a]	1.8	420.0	390.0	[b]
3	9.7	[a]	220.0	450.0	125.0	[b]
4	4.2	320.0	63.0	100.0	74.0	[b]
5	2.5	[a]	79.0	440.0	420.0	[b]
6	8.9	93.0	90.0	880.0	175.0	420.0
7	8.3	[a]	87.0	900.0	220.0	86.0
8	3.3	[a]	189.0	410.0	150.0	[b]
9	3.7	[a]	97.0	380.0	97.0	560.0
10	9.2	[a]	84.0	350.0	79.0	[b]
Carbon	0.8	—	—	—	—	—
Soil base	—	—	0.9	0.1	—	—

[a] Less than 93 ppm.
[b] Less than 86 ppm.

(1.8 ppm) as compared with the other samples. Sample 3 showed the highest amount of boron (220 ppm). The others did not vary greatly in their copper contents. These are corrected values for copper.

Manganese. As expected, the manganese contents of the soil samples showed the highest percentages. Sample 7 gave the highest and sample 4, the lowest values, 900 ppm and 100 ppm, respectively. These are also corrected values.

Nickel. Sample 1 gave the highest percentage (540 ppm) and sample 4 (74 ppm), the lowest.

Zinc. Only samples 6 (420 ppm) and 9 (560 ppm) had amounts higher than the sensitivity limit for zinc in the standards. Sample 7 contained Zn at a concentration of 86 ppm.

Other elements. Cobalt, barium, and cadmium could not be detected below 100 ppm, and molybdenum, below 10 ppm.

Any discrepancies in the values reported may be attributed to the fact that the Littrow-type of spectrograph was specially designed to hold photographic plates. In this study, film strips were only inserted in an improvised film adapter and placed in the plate holder. The lines in the spectrogram showed a tendency to curve near both ends. Consequently, densitometric readings were slightly affected because the whole lines could not be wholly centered on the slit. Nevertheless, the values obtained compared favorably with those of established methods employed at the Bureau of Soil Conservation.

SUMMARY AND CONCLUSION

This study made use of a modified spectrographic method for the analysis of trace elements. It gave results which are helpful in the preliminary analysis of the trace element status of some soils in the Philippines. All the soil samples contained B, Cu, and Mn above 1 ppm which was their sensitivity limit. The boron content of the different soils did not vary greatly (2.5-9.7 ppm), while the copper content varied from 1.8 to 220 ppm. All the soils contained Mn at concentrations above 100 ppm (100-900 ppm). The nickel contents of all soils were much above (74-540 ppm) its sensitivity limit of 10 ppm. Strontium was not detected.

In the samples where no densitometric readings were obtained, the concentrations of the elements were lower than their established sensitivity limits in the standards. This is true of all samples except samples 4 and 6 for Cr and all samples except samples 6, 7, and 9 for Zn. Samples 4 and 6 contained 520 and 93 ppm Cr, respectively; zinc was found to be 86 ppm in sample 7, 420 ppm in sample 6, and 560 ppm in sample 9.

Further studies on the availability of the above elements would be of great significance. This would require concentration procedures

and more standardized laboratory conditions. The spectrographic results should be properly correlated with results from field experiments of crop responses.

LITERATURE CITED

ASTM COMMITTEE E-2 EMISSION SPECTROSCOPY. 1953. Methods for Emission Spectrochemical Analysis. 305 p.

BALLARD, S. S. 1937. Some applications of spectroscopy to agriculture. *Abst. in* Phys. Rev. **52** (11): 253.

ERWIN, T. C. 1950. The use of spectrographic methods in the analysis of soils and of plants and animal tissues in trace element studies. Proc. Soil Sci. of Florida **10**: 83.

LUNDEGARDH, H. and R. L. MITCHELL. 1951. Leaf analysis. London: Helger and Watts, Ltd.

MITCHELL, R. L. 1947. Spectrographic analysis of plants and soils. Biological Rev. Cambridge Philosophical Soc. **22** (1): 1-29.

————. 1948. The spectrographic analysis of soils, plants, and related materials. Commonwealth Bur. Soil Tech. Comm. No. 44.

————. 1955. Spectrochemical analysis of plants and soils. Proc. Soil Sci. of Florida XV: 12.

————. 1957. Spectrochemical methods in soil investigation. Soil Sci. **83** (1): 1-13.

ROGERS, J. H., C. E. GALL, and R. M. BARNETTE. 1939. Distribution of macro and micro elements in some soils of Peninsular Florida. Tech. Bull. Fla. Agric. Expt. Sta. No. 341.

SPECHT, A. W. and J. RESNICKE. 1954. Simultaneous spectrographic procedure and its evaluation for analysis of plant materials. Special reprint, U.S.D.A.

NOTE: ATTEMPTS AT APPLYING NUTRIENTS THROUGH RICE LEAVES

Repeated observations point to the beneficial effects of a top dressing of nitrogen when rice is at the booting stage. The obvious explanation for this is that the increase in chlorophyll content of the leaves resulting from nitrogen fertilization makes the leaves more efficient in photosynthesis, hence the increase in yield.

However, late application of nitrogen has an incidental undesirable effect as it stimulates the production of late tillers which do not head. From the standpoint of grain production, it is a waste of material. The writers speculated that either of two substitutes to late nitrogen application may give the same effect on grain yield without stimulating late production of tillers: (1) spraying with a hormone, like naphthalene acetic acid, in order to promote chlorophyll production, and (2) spraying with simple sugars, like glucose or sucrose, to possibly supplement photosynthesis and increase the storage of starch in the grain.

The results of the pot experiments conducted to explore these possibilities are shown in tables 1 and 2.

There seemed to be no beneficial effect accruing from sucrose sprays either in terms of number of panicles produced or in the yield of grains (table 1). There was a slight favorable ratio of grains to straw.

Successive sprays of NAA from flower initiation to emergence increased the number of panicles but reduced the grain yield. The panicles were very light with much fewer grains than the control. The panicles had difficulty emerging from the leaf-sheath and in many cases they were not fully exserted (fig. 1). The grain-to-straw ratio was very unfavorable.

One spraying of NAA at flower-bud initiation increased the number of panicles and gave the highest yield among the treated cultures.

In the second experiment, the plants were given nitrogen at transplanting time and potassium at 70 days of age. The former treatment was intended to increase tillering and vegetative growth

Fig. 1.—Photographs of rice panicles of Var. Peta showing effect of foliar-sprays of naphthalene acetic acid (NAA) and sucrose on the degree of exsertion. Note failure of panicle to completely emerge from the enclosing leaf-sheath of the flag leaf as a result of NAA treatment.

TABLE 1.—*Effect of naphthalene acetic acid (NAA) and sucrose sprays on yield of rice*

CULTURE NUMBER	TREATMENTS	AVE. NO. OF PANICLES	AVE. WT. OF GRAINS (g)	GRAIN-TO-STRAW RATIO
I	2% sucrose sprayed daily from panicle emergence to grain maturity	96.0	465.27	1:1.5
II	2% sucrose sprayed daily from flower-bud initiation to grain maturity	101.7	477.97	1:1.7
III	300 ppm NAA sprayed daily from flower-bud initiation to emergence	112.7	191.93	1:6.3
IV	300 ppm NAA sprayed once at advanced booting stage	107.0	430.27	1:2.2
V	300 ppm NAA sprayed once at flower-bud initiation	114.3	497.30	1:1.8
VI	300 ppm NAA sprayed once at flower-bud initiation; 2% sucrose sprayed daily from emergence to grain maturity	106.0	445.87	1:2.0
VII	Control (No NAA and no sucrose spray)	102.0	514.10	1:1.7

Variety: Peta
Area of tank: 1 sq. m.; 9 hills
Date planted; harvested: March 23 to Aug. 30, 1958.
No. of plots: 3

and the latter, to increase the stiffness of straw and grain yield. This practice was based on the results of some related experiments in the Department. After these basal treatments, the different cultures were sprayed with sucrose, urea, and NAA.

In general the NAA, urea, and sucrose sprays at about flower emergence did not increase the grain yield over culture I which received nitrogen at transplanting (table 2).

It may therefore be claimed that with the possible exception of the NAA spray at flower-bud initiation (about 75 days), sprays of sucrose, NAA, and urea during flower bud formation up to the maturity of the grains induced no distinct beneficial effect. The apparent contrasting effect of NAA sprayed at different stages of the plant deserves further study.

—*F. C. Manuel and R. S. de la Peña*

TABLE 2.—*Effects of naphthalene acetic acid (NAA), urea and sucrose sprays on yield of rice*

CULTURE NUMBER	TREATMENTS	1959 CROP			1960 CROP		
		Ave. No. of panicles	Ave. wt. of grains (g)	Grain-to-straw ratio	Ave. No. of panicles	Ave. wt. of grains (g)	Grain-to-straw ratio
I	8 g. ammonium sulfate (N) at 30 days	25.3	54.35	1:2.94	16.5	46.90	1:1.93
II	Same as I; plus 8 g. potassium sulfate at 70 days	23.8	56.80	1:2.44	17.9	40.24	1:1.78
III	Same as II; plus 2 g. N at 90 days	23.9	53.24	1:2.46	20.3	49.25	1:2.05
IV	Same as II; plus 100 ppm NAA spray at 100 days	22.3	54.59	1:1.98	16.3	35.01	1:2.23
V	Same as II; plus 0.5% urea spray at 100 days	25.6	49.80	1:2.05	20.0	43.86	1:1.93
VI	Same as II; plus 2.0% sucrose sprays every other day for 10 days starting at 100 days	22.1	49.34	1:2.16	23.6	58.09	1:2.00
VII	Same as II; plus 7.0% hydrolyzed sucrose spray at 100 days	24.0	47.55	1:2.16	19.5	42.48	1:2.24
VIII	Same as II; plus 2% hydrolyzed sucrose and 1% boric acid spray at 100 days	24.6	49.68	1:2.22	20.3	44.08	1:1.93

Variety: Peta
Area of pot: ca. 0.1 sq. m.; 2 hills
Date planted; harvested: for 1959, April 13 to September 17; for 1960, March 11 to August 9.
No. of plots: 4

THE CENTRAL EXPERIMENT STATION

LIST OF AVAILABLE PUBLICATIONS

BOOKS:

Volume I—Field Crops	₱12.00
Volume II—Livestock and Poultry	7.90
Postage	.40

CENTRAL EXPERIMENT STATION BULLETIN:

No. 1—Farm Management, Land Use and Tenancy in the Philippines—*By Horst von Oppenfeld, J. C. Sta. Iglesia, P. R. Sandoval*	₱1.00

CIRCULARS:

No. 1—Perennials in the Arboretum of the College of Agriculture and Vicinity—*By J. V. Pancho and G. C. Lugod*	0.45
No. 33—Kenaf Culture—*By P. A. David*	.30
No. 34—Vanilla Culture—*By P. A. David*	.30
No. 35—Black Pepper Culture—*By P. A. David*	.30

TECHNICAL BULLETINS:

No. 2—Guide to Certified Rice Seed Production	.40
No. 3—Guide to Certified Hybrid Seed Corn Production	.40
No. 4—Common Diseases of Vegetable Crops and Their Control on the Philippines	.70
No. 5—Mushroom culture	.25

All orders for books with remittance should be addressed to

THE DEAN AND DIRECTOR
COLLEGE OF AGRICULTURE AND
CENTRAL EXPERIMENT STATION
COLLEGE, LAGUNA, PHILIPPINES

The Philippine Agriculturist

(Formerly The Philippine Agriculturist and Forester)

Published by the COLLEGE OF AGRICULTURE
AND CENTRAL EXPERIMENT STATION
UNIVERSITY OF THE PHILIPPINES

Vol. I—2
Vol. II—4-6
Vol. IV—3, 5-6, 7
Vol. V—5, 6, 8, 9, 10
Vol. VI—1, 4, 5-6, 7, 8. 9, 10
Vol. VII—1, 2, 3, 4, 5, 7, 8
Vol. VIII—3. 4, 5, 7, 8-9, 10
Vol. IX—3, 4-5
Vol. XI—8
Vol. XIII—3, 5, 6, 9, 10
Vol. XIV—1, 2, 3, 4, 5, 6, 7, 9
Vol. XV—Complete
Vol. XVI—7, 8, 9
Vol. XVII—6, 7, 8, 9, 10
Vol. XVIII—Complete
Vol. XIX—Complete
Vol. XX—Complete
Vol. XXI—Complete
Vol. XXII—Complete
Vol. XXIII—1, 2, 3, 4, 6, 7, 8, 9, 10
Vol. XXIV—Complete
Vol. XXV—Complete
Vol. XXVI—Complete
Vol. XXVII—Complete
Vol. XXXI—1, 2, 3, 4
Vol. XXXII—1. 2, 3, 4
Vol. XXXIII—1, 2, 3, 4
Vol. XXXIV—2, 4
Vol. XXXV—Complete
Vol. XXXVI—1, 2, 4, 5, 6, 7, 8, 9, 10
Vol. XXXVII—1-2, 4, 5-6, 7, 8, 9, 10
Vol. XXXVIII—1, 2-3, 4-5, 6-7, 8
Vol. XXXIX—1, 2, 5, 6, 7, 8, 9, 10
Vol. XL—Complete
Vol. XLI—Complete
Vol. XLII—Complete
Vol. XLIII—Complete

Back copies of Vols. I to XXVII sell at 50 centavos a copy and back copies of Vols. XXXI to XXXIX sell at ₱1.50 a copy.

Send your order to the BUSINESS MANAGER, THE PHILIPPINE AGRICULTURIST, COLLEGE, LAGUNA, PHILIPPINES.